BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

(12) **Offenlegungsschrift**

(10) **DE 44 35 531 A 1**

(51) Int. Cl.[6]:
B 23 K 26/06
G 02 B 5/10
G 02 B 6/00

(21) Aktenzeichen: P 44 35 531.9
(22) Anmeldetag: 5. 10. 94
(43) Offenlegungstag: 20. 4. 95

DE 44 35 531 A 1

Mit Einverständnis des Anmelders offengelegte Anmeldung gemäß § 31 Abs. 2 Ziffer 1 PatG

(71) Anmelder:
Bernhard, Albert, Dipl.-Ing., 83109 Großkarolinenfeld, DE; Kripmann, Manfred, Dipl.-Ing., 57339 Erndtebrück, DE

(72) Erfinder:
Antrag auf Nichtnennung

Prüfungsantrag gem. § 44 PatG ist gestellt

(54) Nd:YAG-Laser-Fokussiereinrichtung zum Schweißen, insbesondere von Blechen

(57) Es wird eine Nd:YAG-Laser-Fokussiereinrichtung zum Anschluß an einen Lichtwellenleiter (LWL) mit ausgangsseitiger Strahlkollimation vorgeschlagen, die dadurch gekennzeichnet ist, daß zur Strahlfokussierung ein als Fokussierspiegel ausgebildetes Paraboloidsegment eingesetzt wird, dessen Oberfläche sehr fein und glatt strukturiert ist und einen hohen Reflexionsgrad bei niedriger Energieabsorption im Bereich der YAG-Laser-Wellenlänge aufweist, wobei der Fokussierspiegel vor Spritzpartikeln und Schweißrauchen durch einen im wesentlichen parallel zur Ebene der Spiegelrandung verlaufenden Cross-Jet-Luftstrahl geschützt wird.

DE 44 35 531 A 1

German Offenlegungsschrift DE 44 35 531 A1

Nd:YAG laser focusing device for welding, in particular of metal sheets

An Nd:YAG laser focusing device for connection to an optical waveguide with beam collimation on the emergence side is proposed, which device is characterized in that a paraboloid segment designed as a focusing mirror, the surface of which is structured such that it is very fine and smooth and has a high reflectance along with low energy absorption in the range of the YAG laser wavelength, is used for beam focusing, the focusing mirror being protected from spatter particles and welding fumes by a cross-jet air stream running essentially parallel to the plane of the mirror border.

Description

Object and state of the art

When welding steel sheets, in particular those with a zinc coating, and when welding aluminium and other metallic materials by means of an Nd:YAG laser beam, glowing material particles often erupt explosively from the molten bath and move at very high speed in all accessible directions.

Also produced are welding fumes, which likewise move in an uncontrolled way and are deposited on surfaces in their vicinity.

Both factors have the effect that the lens optics customary in laser welding become soiled quite quickly on the beam emergence side. For this reason, it is customary to protect the lens optics of the focusing unit by a covering with a transparent protective glass, bloomed by coating, which is fitted between the welding location and the focusing optics.

Furthermore, it is customary also to arrange what is known as a cross-jet device in front of the protective glass. This is a powerful air stream emerging from a Laval nozzle transversely with respect to the axis of the focused laser beam, which is intended to deflect the particles and fumes entering it and thereby prevent soiling of the protective glass.

Keeping the focusing device clean for the unhindered passage of the laser beam is important because

a) soiling leads to inadequate energy throughput and consequently to defective welds, and
b) as the degree of soiling increases, the energy absorption of the protective glass may become so high that it is damaged by excessive thermal

loading.

To avoid defective welds and repairs to the laser welding device, the current state of the art provides for the precautions described above to be taken.

In spite of the cross-jet device, particles are still deposited on the protective glass to an excessive degree, with the result that it is scarcely possible to achieve a service time of, for example, 8 hours without a gradual reduction in the welding performance. One explanation for this is that the effect of the cross-jet air stream on the glowing spatter particles is relatively short in terms of distance and time and, for design reasons, can also be scarcely improved appreciably.

Consequently, the object here is to design a focusing device for Nd:YAG laser welding applications in such a way that a considerably longer service time in comparison with the current state of the art is achieved along with significantly better efficiency.

Solution proposal

According to the invention, it is proposed as a solution for achieving the stated object that a paraboloid segment designed as a focusing mirror, which is preferably made of copper and the surface of which is structured such that it is very fine and smooth and has a high reflectance along with low energy absorption in the range of the YAG laser wavelength, should be used for beam focusing, the focusing mirror being protected from spatter particles and welding fumes by a cross-jet air stream running essentially parallel to the plane of the mirror border and at an angle deviating from the axis of the focused beam in the range of 30° ... 50°.

The use of a focusing mirror makes it possible here to allow the cross-jet air stream to act considerably longer on the spatter particles, since the cross-jet then no longer flows in transversely with respect to the focusing axis, as in the case of lens optics, but at an angle appreciably smaller than 90° with respect to the focusing axis.

This achieves the effect that

a) intensified cooling of the particles during their flight takes place, and
b) the deflection of the particle trajectory in the desired direction, heading away from the focusing device, is considerably improved.

Investigations have shown that, as a result, not only the soiling of the focusing device in itself becomes less, but at the same time the type of remaining deposits also changes inasmuch as now they are considerably cooler particles, which can be easily wiped away with a suitable cloth, since they no longer become lodged in the surface - as is the case with glowing parts.

A precondition for the service time to be prolonged and the cleaning of the focusing device to be made easier in this way is the use according to the invention of a focusing mirror together with an obliquely set cross-jet.

An additional advantage is obtained in an embodiment of the focusing device according to the invention which provides that the collimation device is in this case mounted rotatably in such a way that the entry of the optical waveguide into the collimation system takes place virtually without any buckling loads being exerted on the optical waveguide, even if rapid relocating movements are performed.

For this purpose, the collimation device is pivotably mounted concentrically with respect to its exit axis.

In an embodiment of an especially small form of the focusing device according to the invention, a plane mirror is also arranged in the path of rays between the emergence from the collimation and the impingement on the focusing mirror, combining with the focusing mirror to allow the construction of a focusing device in which the plane running perpendicularly with respect to the axis of the laser beam deflected by the plane mirror and through the axis of the collimation is preferably arranged parallel to the axis of the focusing.

The invention is described in detail below on the basis of Figures 1 to ....

Figure 1 shows an Nd:YAG laser focusing device according to the invention, approximately on a scale of 1:3, built onto the tool flange of an industrial robot. The following designations are used:

1 optical waveguide, flexible
2 collimation device
3 protective glass for 2
4 outlet opening(s) for a cross-jet air stream
5a, b, c outer and central laser beam components after emerging from the collimation device
6 focusing mirror (water-cooled; cooling not shown)
7 focusing mirror block
8 cross-jet device with the individual nozzles 8a to 8f
9 compressed-air connection for cross-jet
10 adjustable annular nozzle for supplying inert gas (inert gas connection not shown)
11a, b, c outer and central laser beam components after deflection and focusing by the focusing mirror
12 securing bracket for focusing device
13 fastening flange of the focusing device

14 tool flange of the robot
15 6th axis (outer hand axis) of the robot
16 5th axis of the robot (penultimate hand axis)
17 plane running through the focusing mirror border
f focal length of the focusing device (preferably in the range f = 130... 200 mm).

As can be seen, in this example of a focusing device according to the invention, a focusing mirror with approximately 60° beam deflection has been chosen for the central beam. This allowed the effect to be achieved that the overall arrangement, including the collimation, can be arranged at a relatively small distance from the robot hand axes.

Figure 2 represents an extension of the solution shown in Figure 1, in which the collimation device is pivotably arranged by means of a mounting:
22 mounting of the collimation device;
with 18, securement for the optical waveguide,
the optical waveguide is in this case restrained in such a way that, when there are lateral deflections of the focusing device, the optical waveguide is capable of pivoting the collimation device. As a result, the buckling loading for the optical waveguide is considerably reduced.

Figure 3 shows the front view,

Figure 4 shows the side view and

Figure 5 shows the rear view of a particularly advantageous embodiment on a scale of approximately 1:2, which takes up only little space, along with great mobility of the system at the same time. This embodiment is additionally equipped with
22a, b two pivot bearings for the collimator (increases the rigidity)
19a, b return springs for the collimation pivoting

movement

20 plane mirror (water-cooled; cooling not shown)

21 plane mirror block

and consequently allows the construction of a focusing device in a very slender overall form of construction.

The embodiments represented in the figures are to be regarded as examples of the forms which the invention may take. They do not in any way restrict the content of the invention.

Patent claims

1. Nd:YAG laser focusing device for connection to an optical waveguide with beam collimation on the emergence side, characterized in that a paraboloid segment designed as a focusing mirror, which is preferably made of copper and the surface of which is structured such that it is very fine and smooth and has a high reflectance along with low energy absorption in the range of the YAG laser wavelength, is used for beam focusing, the focusing mirror being protected from spatter particles and welding fumes by a cross-jet air stream running essentially parallel to the plane of the mirror border and at an angle deviating from the axis of the focused beam in the range of 30° ... 50°.

2. Nd:YAG laser focusing device according to Claim 1, characterized in that the collimator is movable around a central position in an angle range of approximately ± 45° about an axis lying concentrically with respect to the axis of the rays emerging from the collimator and, for this purpose, is rotatably mounted.

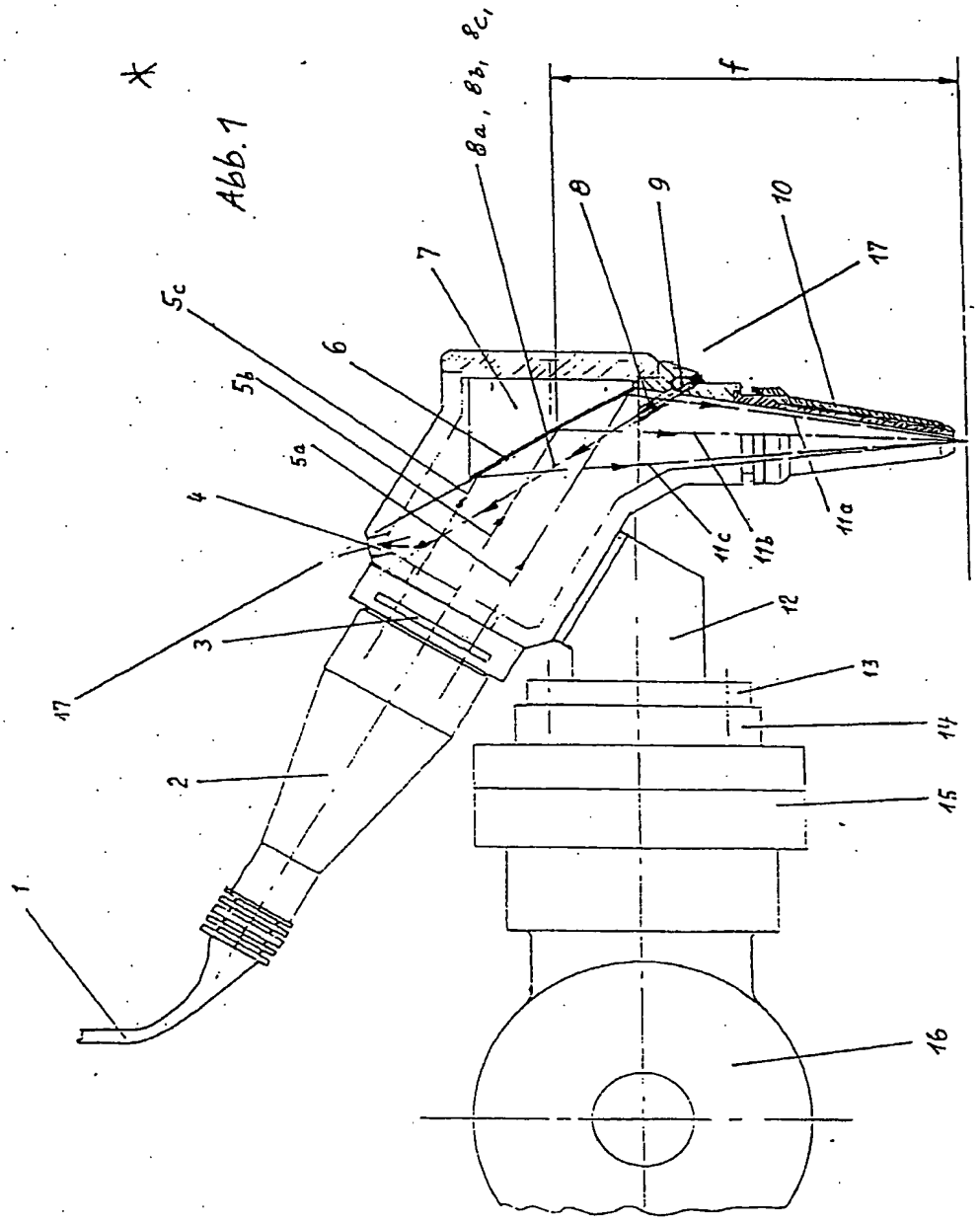
3. Nd:YAG laser focusing device according to Claim 2, characterized in that, in the absence of external deflecting forces, the collimator is secured in its central position by a resilient restraint.

4. Nd:YAG laser focusing device according to Claim 1, characterized in that the parallel-directed laser beam emerging from the collimation is deflected by means of a plane mirror onto the focusing mirror, the plane running perpendicularly with respect to the axis of the laser beam deflected by the plane mirror and the axis of the collimation preferably being arranged parallel to the axis of the focusing.

5 associated pages of drawings

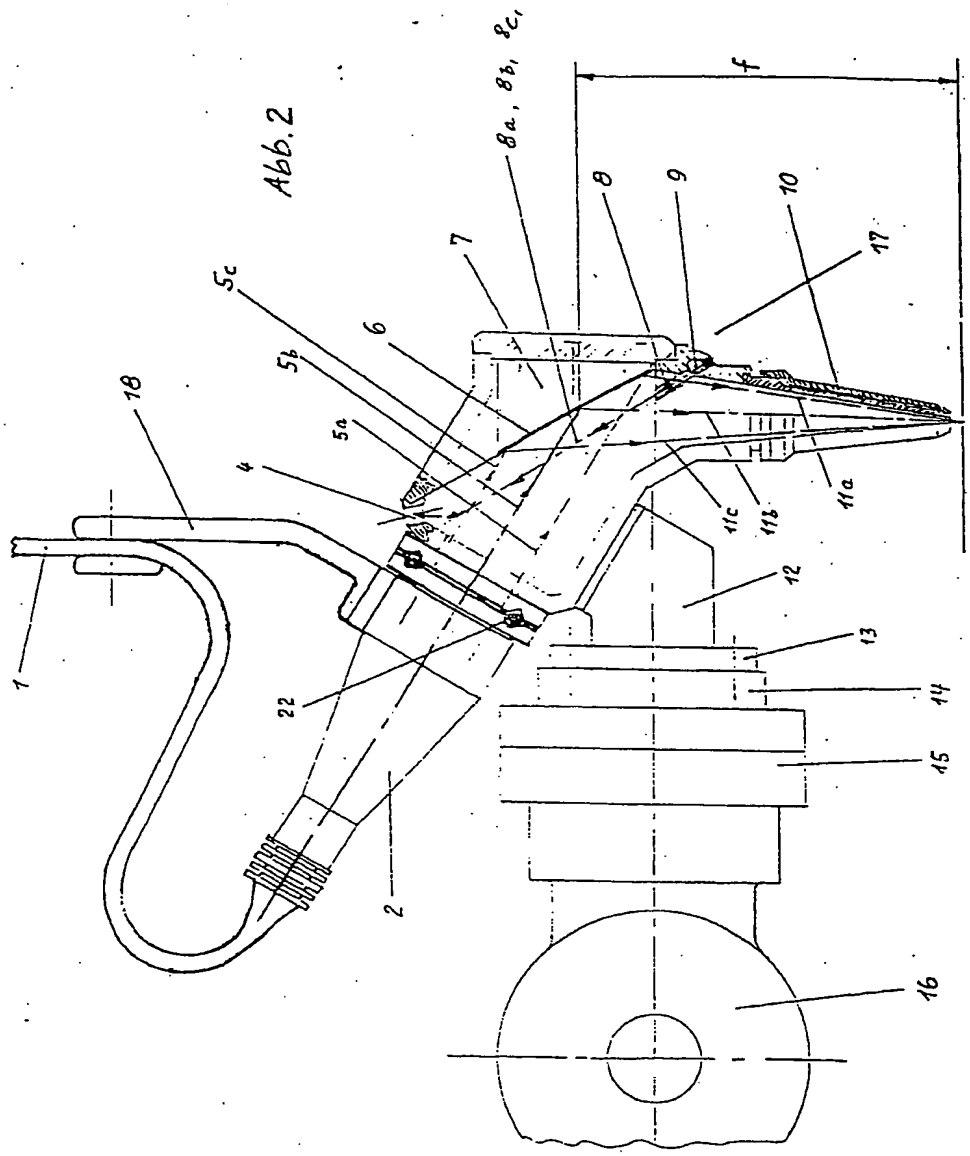
DRAWINGS PAGE 1

Number: **DE 44 35 561 A1**
Int.Cl.[6]: **B 23 K 26/06**
Date laid open: 20.April 1995



DRAWINGS PAGE 2

Number: **DE 44 35 561 A1**
Int.Cl.[6]: **B 23 K 26/06**
Date laid open: 20.April 1995



Number: **DE 44 35 561 A1**
Int.Cl.[6]: **B 23 K 26/06**
Date laid open: 20.April 1995

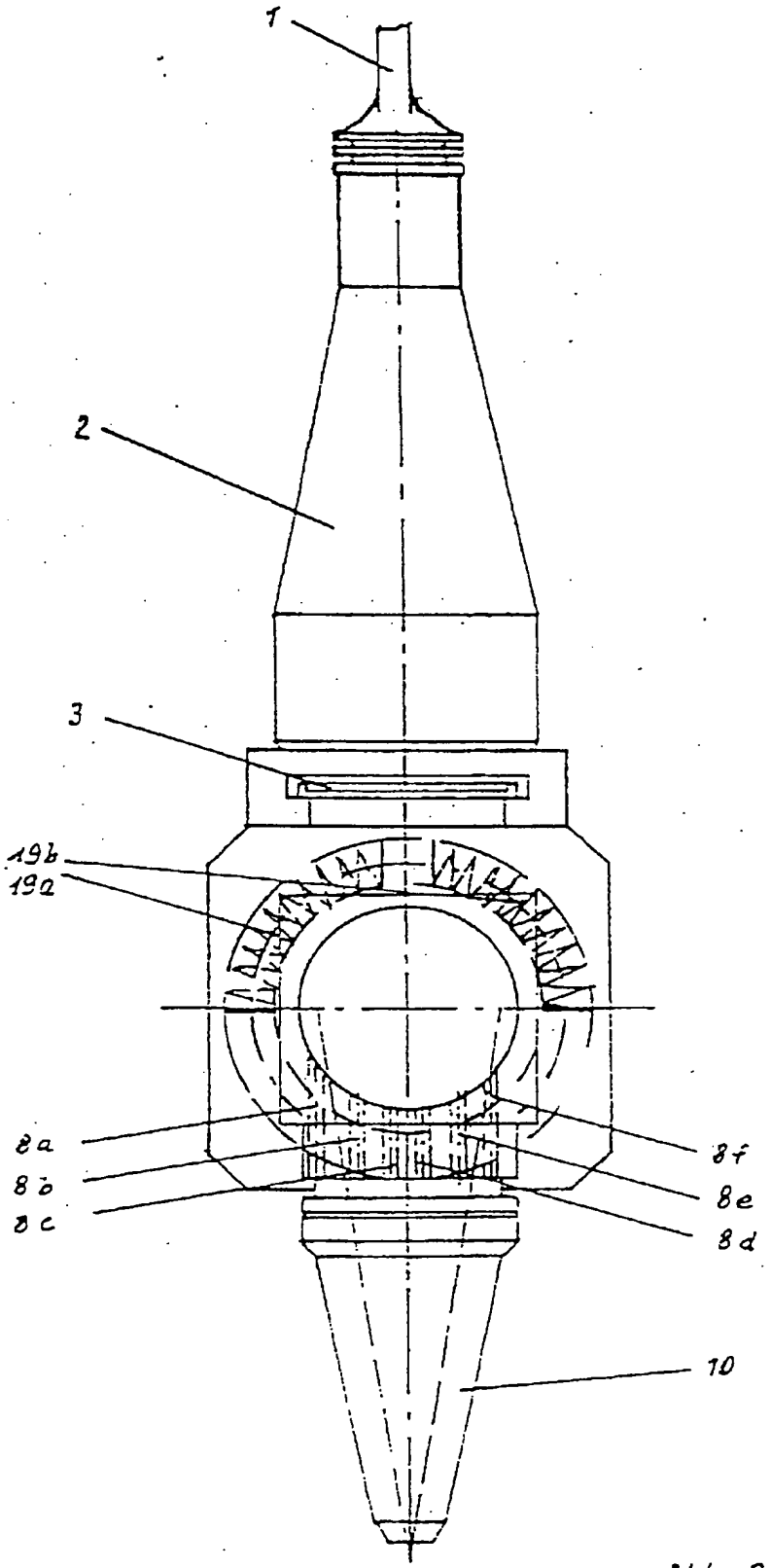


Abb. 3

Number: **DE 44 35 561 A1**
Int.Cl.[6]: **B 23 K 26/06**
Date laid open: 20.April 1995

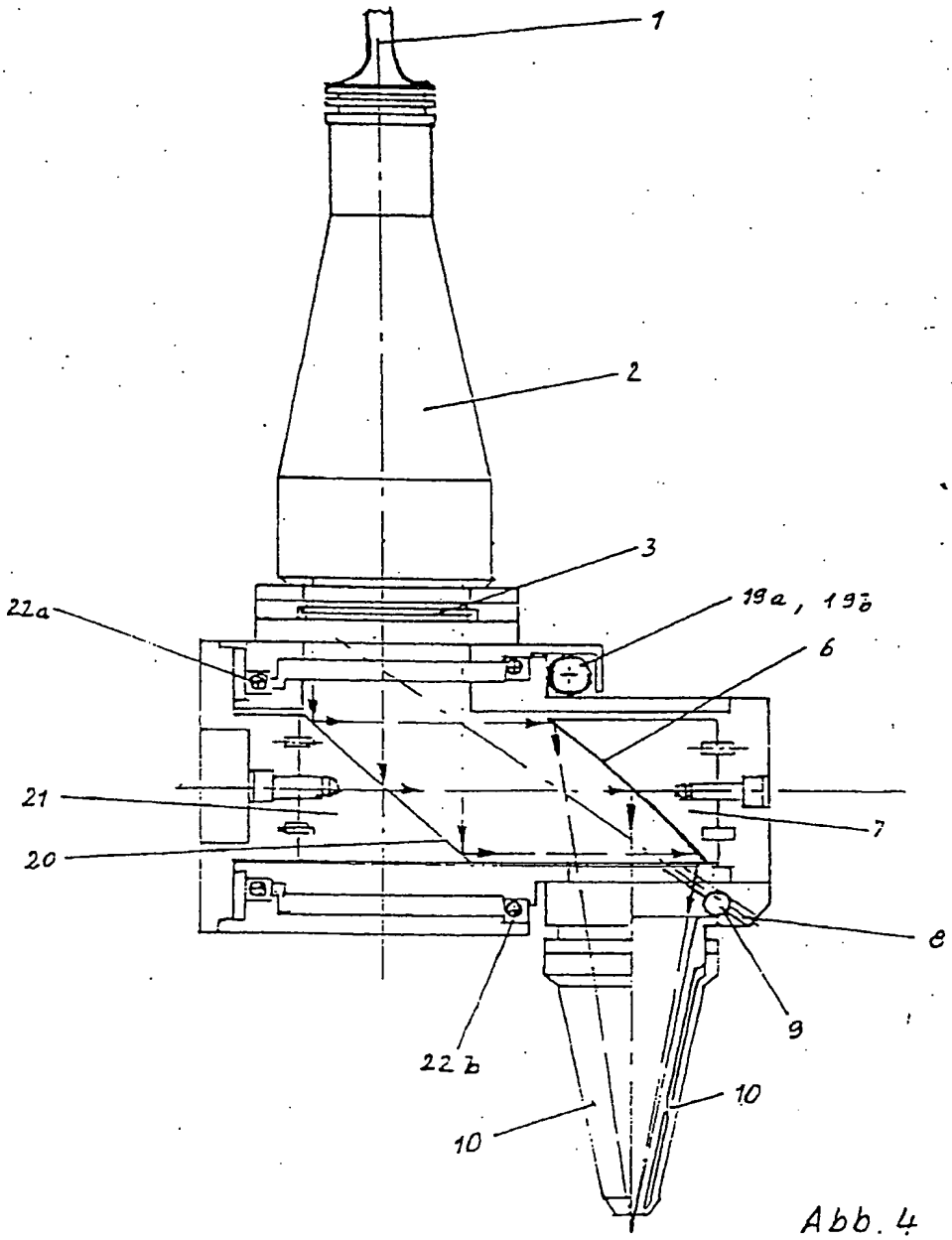


Abb. 4

Number: **DE 44 35 561 A1**
Int.Cl.[6]: **B 23 K 26/06**
Date laid open: 20.April 1995

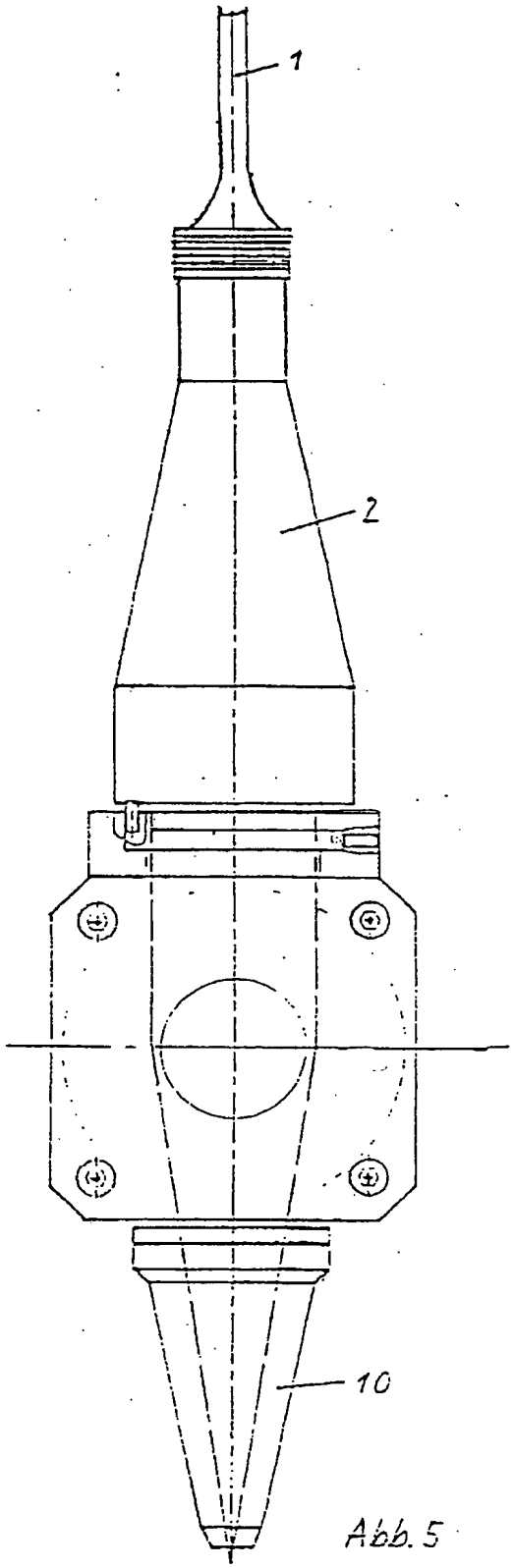


Abb. 5